SOME POTENTIAL RISKS AT LOWER LEVELS OF STRATEGIC NUCLEAR WEAPON ARSENALS

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13. ABSTRACT *(Maximum 200 words)* An examination of the some of the risks if both the U.S. and Russia were to reduce their strategic nuclear inventories in future arms control environments. The risks considered include: loss of deterrence, launch on warning, and breakout or cheating. Assumed weapon limits for both sides included START III and a limit of 800 warheads on each side.

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PREFACE

This report presents discussions and analyses of some of the risks that might be encountered if both the U.S. and Russia were to reduce their strategic nuclear weapon inventories in future arms control environments. The potential risks include: the dimunition of strategic deterrence between the U.S. and Russia, the susceptibility of either or both sides to sudden attacks with launch on warning responses, and the implications of cheating or breakout in terms of numbers of weapons on either or both sides. The limits on strategic nuclear weapons for both sides include the proposed START III level of 2000-2500 warheads, and a lower potential limit of 800 strategic nuclear weapons.

This report was prepared for the U.S. Arms Control and Disarmament Agency. It should be of interest those those concerned with arms control in the defense community, and others whose efforts are related to national security aspects of strategic nuclear forces.

None of the material contained in this report should be construed to represent the official views of the U.S. Arms Control and Disarmament Agency, the Department of Defense, or any other organization within the U.S. Government.

The author wishes to thank Sarah Mullen, Robert Batcher, and James Scouras of ACDA for their interest, comments, and support. The author is particularly indebted to Glenn A. Kent of the Rand Corporation for his insights and pointed comments on an early draft. The contents of this report are the sole responsibility of the author, a consultant to ACDA (IVI/ITA).

CONTENTS

RISKS.MSS

I - INTRODUCTION

The purpose of this report is to examine some of the risks that might be encountered at lower levels of strategic nuclear warheads in the arsenals of the U.S. and Russia. While START II has not yet been ratified by the Russian government, Presidents Yeltsin and Clinton have agreed to accords beyond the limits of the START II Treaty [1]. These accords may form the framework for a future treaty, START III.

In this report, the focus will be to examine some risks at potential START III levels, and also to consider these risks at a much lower level of strategic nuclear warheads, 800 on each side. In addition to displaying the methodology (Chapter II), and providing the reader with the myriad of needed assumptions (Chapter III), a variety of risks are considered in this report.

When nuclear weapons are reduced beyond the START II levels, there is a concern that there could be a dimunition of deterrence, or even a loss of deterrent capabilities. Chapter IV addresses these concerns in terms of central deterrence and first strike stability.

Launch on warning tactics have been a concern to both the U.S. and Russia for many years. Would such tactics result in more severe consequences at lower levels of nuclear inventories? Chapter V provides a discussion of some of the more salient aspects of such tactics.

When future arms control agreements are considered, analysts in both the arms control and defense communities often wish to provide adequate verification measures to assure that neither side will be able to surreptitiously cheat or "break out" from such agreements. Chapter VI provides some insights into the possible consequences of cheating or breakout, particularly in terms of increased first strike damage and first strike stability.

Final observations are provided in Chapter VII of this report. These observations will summarize the findings of the various analyses presented of each of the concerns discussed in the report. The reader is cautioned that there may be other problems that are not considered here. The scope of this report may be incomplete in that respect.

II - METHODS OF ANALYSIS

This chapter outlines methods of analysis used in examining each of the topics discussed in this report. These include: analysis of direct attacks on population centers, first strike stability, anti-ballistic missile defenses, and Bayesian methods for updating probabilities as new information is gathered.

Population Attacks

To consider population attacks, data concerning the distribution of population in the United States and Russia will be employed. In the analysis to follow, attacks are ordered by either population density, or by the population of the cities involved. For the U.S., attacks were assumed to be ordered on the basis of population density (population per square mile). For Russia, attacks were assumed to be ordered on the basis of the population of the city in question. For the U.S., it was assumed that the portion of the population involved in the consequences of the attack would be persons living in an area covered by an overpressure of 1 psi (pounds per square inch). For Russia, the allocation of warheads was based on a rule of thumb - each person in the particular city would be allocated one equivalent ton of TNT in the form of nuclear explosives.

First Strike Stability

The analysis of first strike stability follows the form of its principal authors Glenn Kent and David Thaler [2,3]. The analysis is based on a scenario from which the equations and mathematical manipulations are derived.

The scenario used as a basis for examining first strike stability involves two participating nations, Russia and the U.S. The method involves first strikes by both parties. The first striker generates strategic forces and allocates warheads to minimize the surviving worth of each target. In this analysis, the worth of a given target is the number of warheads it contains. The first striker then sends enough warheads against the defender's strategic forces to minimize his "cost." The first striker's remaining warheads are then allocated to the "value" targets of the defender. The defender retaliates by aiming all of his surviving warheads against the first striker's "value" targets.

The terms "cost" and "value" have very specific meanings in the analysis of first strike stability. The cost to the U.S. and to Russia are given by equations where cost is a function of the damage suffered and the damage not inflicted on the opposing party. The cost to Russia is given by

$$(1) \quad C(FSU) = D(FSU)^{0.75} + 0.3 \cdot [1 - D(US)^{0.75}]$$

and the cost to the U.S. is given by

$$(2)\quad C(US) = D(US)^{0.75} + 0.3\cdot[1 - D(FSU)^{0.75}]$$

where C(FSU), C(US) are the costs to Russia and the U.S., and D(FSU), D(US) are the fraction of value targets damaged in Russia or the U.S. in the first strike or in a retaliatory strike.

The valued assets of the U.S. and Russia are assumed to consist of other military targets supporting nuclear operations, weapons of mass destruction, conventional forces, defense supporting industry, leadership, and other industries. These groups of installations are often referred to as "other military targets" by military strategists. One analysis of Russian targets [4] indicates that about 95% of value targets are contained in 2400 aimpoints, and the distribution of value is approximately exponential in nature. The exponential distribution is given by

$$(3)\quad \text{Value at risk} = 1 - e^{-WH/SF}$$

where WH represent the arriving warheads and SF is a scale factor, approximately 800 for the Russian target system.

The index of first strike stability is the product of two cost ratios. The ratios are the cost of going first to the cost of waiting to be struck, for each side. Thus,

$$(4)\quad FSS = \frac{C(\text{US FIRST})\cdot C(\text{RUSSIA FIRST})}{C(\text{US SECOND})\cdot C(\text{RUSSIA SECOND})}$$

where FSS is the index of first strike stability. The costs are estimated by assuming that both the U.S. and Russia strike first. When the first strike stability is high, approaching unity, neither side is tempted to strike first, and the situation is stable. When the first strike stability is low, approaching zero, either one side or both are tempted to strike first and the situation is approaching instability.

Anti-Ballistic Missile Defenses

Since very little is known about the qualities of future anti-ballistic missile defenses (ABM), a simple representation of their effectiveness is used in this report.

The fraction of attacking re-entry vehicles (RV) penetrating an ABM system is given by

$$(5)\quad P(pen) = [1-fp(I/RV)]\cdot L^{INT(I/RV)} + fp(I/RV)\cdot L^{INT(I/RV+1)}$$

where fp(x) represents the fractional part of the quantity x, INT(x) represents the integer part of x, L is the leakage (or 1-k

where k is the single shot probability of kill of the interceptors, on average), I is the number of ABM interceptors, and RV is the number of RVs in the attack. If perfect decoys are deployed by the attacker, RV then represents the total number of re-entering objects - RVs and decoys. No decoys are assumed in this analysis.

Bayesian methods

Later, when considering launch on warning responses to an attack, Bayesian techniques are employed for updating information as more warning reports are generated and sent to a commander. The method of analysis can be derived from first order definitions used in probability theory [5]. The model starts with the predisposition of the commander as to the liklihood of an attack [13]. Subsequently, the probability of an attack given warning is modified based on the receipt of warning messages. The formulation is given by

$$(6) \quad \mathrm{Post}(A|W) = \frac{P(W|A)\cdot \mathrm{Prior}(A)}{P(W|A)\cdot \mathrm{Prior}(A) + \{P(W|NA)\cdot[1 - \mathrm{Prior}(A)]}$$

$$(7) \quad \mathrm{Post}(A|NW) = \frac{P(NW|A)\cdot \mathrm{Prior}(A)}{P(NW|A)\cdot \mathrm{Prior}(A) + \{P(NW|NA)\cdot[1 - \mathrm{Prior}(A)]}$$

where Post(A|W) is the posterior estimate of an attack given warning, Post(A|NW) is the posterior estimate of an attack given no warning, P(W|A) is the probability that a warning message is produced given that there is an attack, P(W|NA) is the probability that a warning message is produced when there is no attack, P(NW|A) is the probability that no warning message is generated given an attack, and P(NW|NA) is the probability that no warning message is generated when there is no attack. Prior(A) is the *a priori* opinion of the commander that an attack is likely stated as a probability. Each time there is a warning or no warning message, a posterior probability is produced. This posterior probability becomes the input, or Prior(A), for the next cycle. Thus, as warning messages are produced as an attack is detected, the opinion of the commander is modified by the receipt of information from the warning system. As more and more messages are received, the commander may gain more and more confidence that an attack is underway (equation 6), or is not underway (equation 7). Equations 6 and 7 are simply modifications of Bayes' theorem as used by social and political scientists in their study of how opinion or decisionmaking is swayed by introducing data related to the decision to be made.

III - ASSUMPTIONS

The purpose of this chapter is to outline the assumptions used in the analyses to follow. The assumptions include descriptions of force structure, force posture, parameters related to anti-ballistic missile defenses (ABM), distribution of valued assets in Russia and the U.S., and the distribution of the population of Russia and the U.S. Assumptions concerning force structures and postures if either Russia or the U.S. or both should "break out" from the terms of future treaties will be presented in a later chapter.

Assumed Future Force Structures

In this set of analyses, the concern is to address possible risks under the terms of the proposed START III accords and a lower limit of 800 strategic nuclear warheads for each side, Russia and the United States. Table 1 indicates the force structures assumed for both sides under the START III accords and Table 2 indicates the assumptions about force structures under a limit of 800 warheads.

Table 1 - Assumed Force Structures, START III

Weapon	Loading	Warheads
United States		
Minuteman	1 RV/ICBM	488
Trident	12 SSBN, 24 SLBM/SSBN, 4 RV/SLBM	1152
B-52	27 Aircraft, 20 Warheads/aircraft	540
B-2	20 Aircraft, 16 Warheads/aircraft	320
	Total Warheads = 2500	
Russia		
Silo ICBMs	1 RV/ICBM (105 RS-18, 139 RS-12)	244
RS-12 MOB	1 RV/ICBM (Mobile, 40 Garrisons)	360
Typhoon	6 SSBN, 20 SLBM/SSBN, 8 RV/SLBM	960
Delfin	7 SSBN, 16 SLBM/SSBN, 4 RV/SLBM	448
TU-95	23 Aircraft, 16 Warheads/aircraft	368
TU-160	10 Aircraft, 12 Warheads/aircraft	120
	Total Warheads = 2500	

Notes: SSBNs are strategic nuclear submarines
SLBMs are sea launched ballistic missiles
ICBMs are intercontinental ballistic missiles
RVs are re-entry vehicles for SLBMs and ICBMs
RS-18 is the SS-19 (NATO designator)
RS-12 is the SS-25 or its follow-on ICBM
RS-12 MOB is a mobile ICBM

Table 2 - Assumed Force Structures, Limit = 800 Warheads

Weapon	Loading	Warheads
United States		
Minuteman	1 RV/ICBM	48
Trident	9 SSBN, 24 SLBM/SSBN, 2 RV/SLBM	432
B-2	20 Aircraft, 16 Warheads/aircraft	320
	Total Warheads = 800	
Russia		
RS-12	1 RV/ICBM (Mobile, 40 Garrisons)	360
Delfin	5 SSBN, 16 SLBM/SSBN, 4 RV/SLBM	320
TU-160	10 Aircraft, 12 Warheads/aircraft	120
	Total Warheads = 800	

These assumptions are those attributed to each side by the author. The force structures under START III are based on extensions of the Nuclear Posture Review [6], and for the Russians on an article by a Russian analyst [7]. They may not conform to actual future force structures. The assumed structures are based on a broad assumption that both sides will try to preserve a triad of strategic forces at levels lower than START II. Each base for weapons is vulnerable to nuclear attack. In this analysis it is assumed that the probabilitiy of damage to silos is 0.6, to submarine docks is 0.7, to bomber airfields is 0.8, and to garrisons housing mobile ICBMs is 0.8. The probabilities that warheads are available and that their carrier vehicle is reliable during flight (0.8) is included in these estimates of damage.

Strategic Force Postures

The postures of strategic nuclear forces are indications of the alert level of ICBMs and bombers, and the at-sea rates of strategic submarines. Two postures will be shown. Posture A is similar to the present state of affairs - no bombers on strip alert, and an assumed low level of alert for mobile ICBMs. Since it is difficult to detect the actual alert rate of ICBMs housed in silos, it is assumed that all ICBMs in silos are on full alert (1.0). The at-sea rates of strategic submarines are estimates made by the author. The at-sea rates assumed for Russian submarines may be optimistically high. One naval expert has alluded to this condition, "Today, however, the startling deterioration of Russia's military plant, including nuclear-powered submarines rusting at their piers,....." [8, p 54]. At present, no bombers on either side are on strip alert in accordance with an agreement between Presidents Bush and Yeltsin. Posture B indicates estimates of the fraction of the bombers that might be put on alert near air-strips if ordered to do so. This estimate is based on former day-to-day alert postures maintained by the United States before 1990.

Table 3 - Potential Force Postures

Weapon System	Postures A	Postures B
U.S., START III		
Minuteman ICBMs	1.0	1.0
Trident SSBNs	0.67	0.67
B-52 Bombers	0.0	0.33
B-2 Bombers	0.0	0.3
Russia, START III		
Silo based ICBMs	1.0	1.0
Mobile ICBMs	0.0	0.33
Typhoon SSBNs	0.33	0.33
Delfin SSBNs	0.29	0.29
TU-95 Bombers	0.0	0.3
TU-160 Bombers	0.0	0.3
U.S., Limit = 800 Warheads		
Minuteman ICBMs	1.0	1.0
Trident SSBNs	0.67	0.67
B-2 Bombers	0.0	0.3
Russia, Limit = 800 Warheads		
Mobile ICBMs	0.3	0.8
Delfin SSBNs	0.4	0.4
Tu-160 Bombers	0.0	0.4

(Note: NO Launch on Warning assumed.)

Strategic Defenses

The strategic defenses for both the U.S. and Russia are assumed to consist of air defenses and anti-ballistic missile defenses. In this analysis, it is assumed that any bomber weapons surviving an attack on either side will penetrate air defenses with a probability of 0.8.

The ABM defenses for each side are represented by a random subtractive defense model. No countermeasures, such as decoys, are assumed for either side. The number of ABM interceptors will be varied, but the leakage rate for re-entry vehicles is assumed constant at 0.3 until defense interceptors are exhausted.

Distribution of Valued Assets

The valued assets, called value targets, on each side are assumed to consist of other military targets, power projection, conventional forces, defense supporting industries, leadership

facilities, and other industries. In this analysis, the value of the total target set is assumed to be exponentially distributed,

(8) Value = 1 - EXP(-WH/SF),

where WH are the delivered warheads aimed at the valued assets, and SF is a scale factor. For the Russian target set, the scale factor is 800, corresponding to 95% of value contained in 2400 aimpoints [4]. For the U.S., the assumed scale factor is 1000, corresponding to 95% of value contained in 3000 aimpoints.

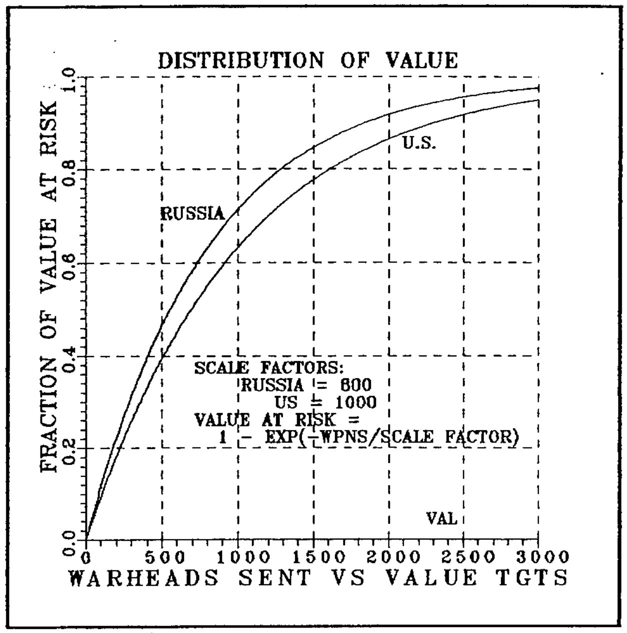

Figure 1

Distribution of Population

In examining one strategy for maintaining deterrence at lower levels of strategic nuclear warheads, namely city-busting, the distribution of population of the U.S. and Russia could be important. For the U.S., the data used in this analysis is based on the 1990 Census conducted by the U.S. Department of Commerce. For Russia, the distribution of population is based on estimates for 1996 [9].

IV - LOSS OR DIMUNITION OF DETERRENCE

One possible risk at lower levels of strategic nuclear arsenals could be a diminished degree of deterrence. The purpose of this chapter is to examine such possibilities under two quite different criteria: Central Deterrence and First Strike Stability.

Central Deterrence

National security analysts have traditionally debated strategic forces and arms control measures in terms of central deterrence. To provide central deterrence, the United States seeks to ensure that Russia would never conclude that it would enjoy substantial gains should it initiate a nuclear exchange. Under this one-sided calculus, the Russian leadership always should conclude that the cost (measured in terms of damage to its valued assets) of striking first would exceed greatly the cost of maintaining the status quo (no nuclear exchange).

Historically, U.S. policymakers have structured U.S. strategic forces to underwrite the objective of central deterrence by avoiding any posture that might tempt the former Soviet Union (now, Russia) to strike the United States. In the 1960's, then Secretary of Defense Robert S. McNamara put forth his policy of Assured Destruction to support central deterrence. As it evolved, he presented the following definition to the Congress in 1965.

"A vital first objective to be met in full by our strategic nuclear forces is the capability for Assured Destruction. What kinds and amounts of destruction we would have to be able (to) inflict in order to provide this capability cannot be answered precisely. But, it seems reasonable to assume the destruction of, say, one-quarter to one-third of its population and about two-thirds of its industrial capacity......would certainly represent intolerable punishment to any industrialized nation and thus should serve as an effective deterrent." [10]

Within the Department of Defense, it was thought that a retaliatory strike of about 400 equivalent megatons (EMT) would meet the definition of Assured Destruction. By the numbers of strategic weapons available to the U.S. during the cold war (more than 10,000 warheads), 400 one megaton weapons or their equivalent seemed to be a small number. Looking back and forward, 400 EMT might yet provide deterrence against Russian attack, provided the reader accepts the notion that 400 or so nuclear warheads could inflict intolerable levels of damage. Under the Assured Destruction doctrine, the value destroyed was the population (cities) and industry in general. In more recent times, targeting has shifted away from killing people to aiming weapons at military facilities used in power projection, war

supporting industries, and leadership bunkers, or other military targets in the current venacular. Even under this somewhat changed emphasis, targeting war supporting and other industries would result in many casualties because most of the factories and support facilities are located in Russian and American cities.

In this part of the analysis of central deterrence, we focus on the number of people affected by a nuclear attack with the weapons surviving a first strike. First, the number of surviving weapons for each side will be estimated, assuming a first strike. Then, the number of people affected by such an attack will be estimated. The underlying thought behind such an analysis is that even at low levels of nuclear weapons, there still might be enough surviving weapons to enforce a strategy of city busting. Such a strategy would be nearly a last resort, but it was the strategy employed when nuclear forces were meager by comparison with those deployed during the height of the cold war. The U.S., and perhaps Russia, might need to re-examine population attacks if nuclear arsenals were drastically reduced below current or even START II levels.

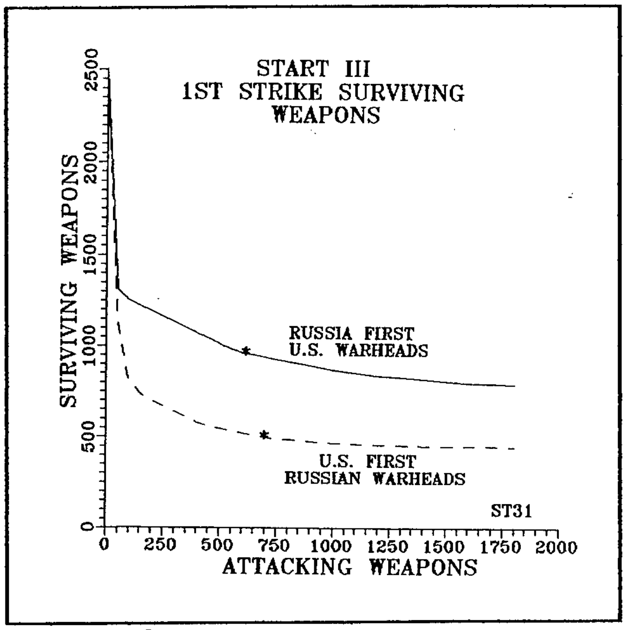

Figure 2

For purposes of this analysis, it is assumed that a first striker would attack the other side's nuclear arsenal. The number of weapons involved in this part of the attack would be determined by minimizing the cost of the exchange to the attacker. Figure 2 indicates the drawdown of strategic weapons under START III levels (2500 warheads) assuming that either the U.S. or Russia would strike first. The points on the curves indicated by a large dot show how many attacking weapons are allocated against strategic nuclear weapon bases to minimize the cost. Larger attacks would have a minimal payoff to the first striker. The remaining weapons would be allocated against valued assets, or cities. If Russia were to strike first, 950 U.S. nuclear warheads would survive the attack. If the U.S. were to strike first, 490 Russian warheads would be expected to survive. The lower number of Russian warheads surviving is directly related to the assumed lower at-sea rate of Russian submarines, compared to that of U.S. submarines. Another assumption also contributes to these results, namely, that Russian mobile ICBMs are not deployed, but are located in

garrisons where they are very vulnerable to attack. Both curves are based on the assumption that Posture A represents the current readiness situation.

Under a mutual limit of 800 strategic nuclear warheads for the two sides, the surviving warheads remaining after a first strike are estimated to be lower than under the START III terms. Figure 3 indicates the drawdown of strategic nuclear warheads as a function of attack size. The heavy dots indicate attack sizes where the attacker's cost is minimized. The residual survivors on either side are expected to be slightly less than 300 warheads.

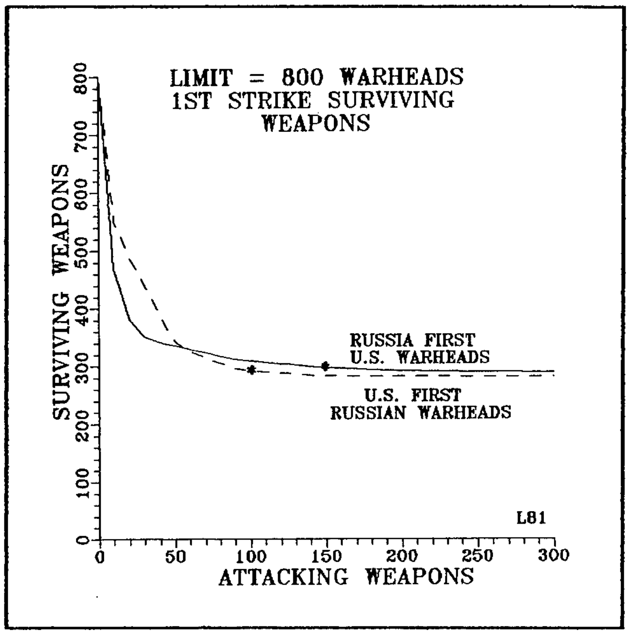

Figure 3

Aspects of Central Deterrence

Central deterrence may depend on what aimpoints are selected for retaliatory strikes by either side. In the above examples, the surviving residual from expected first strikes could be applied to a variety of target sets. In this section of this report, strikes against population are considered.

If the United States were to strike first, Russian nuclear warheads used in a retaliatory strike could be aimed at the U.S. population. Under this scenario, what would be the consequences of such a retaliation? Figure 4 indicates the results of various attack sizes. These results are based on a Russian attack where weapons are delivered in order of the population density as indicated by the 1990 census [11]. The actual cities under attack and the population are detailed in the appendix to this report. The results also are based on the criterion that each metropolitan area is blanketed with an overpressure of at least one pound per square inch (1 PSI). Under the terms of the mutual assured destruction doctrine (25% to 33% population affected), the number of warheads needed would be between 72 and 127, assuming one megaton (1 MT) warheads are used. This number of warheads is well within the residuals shown in previous examples under either the terms of the START III accords or a limit of 800 strategic nuclear warheads. Thus, at least one part of the assured destruction doctrine would be met. Conversely, if the Russians were to strike first, then the effect of an American retaliatory strike would need to be considered. Figure 5

indicates the portion of the Russian population that would be affected by a retaliatory strike as a function of the number of weapons involved. These results are based on estimates of Russian population for the year 1996. Additionally, the U.S. allocation of weaponry is assumed to be based on delivering one megaton for each one million people in each city, according to the equation Warheads/city = INT[population(millions)] + 1. The number of 1 MT warheads needed to affect 25% of the Russian population is estimated to be 52. For a 33% criterion, 78 warheads would need to be delivered. Again, this number of warheads would be available for an American retaliation within the residual left by a Russian first strike. Thus, we conclude that central deterrence, based on population attacks, would not be diminished even under the lower limit of 800 warheads for each side.

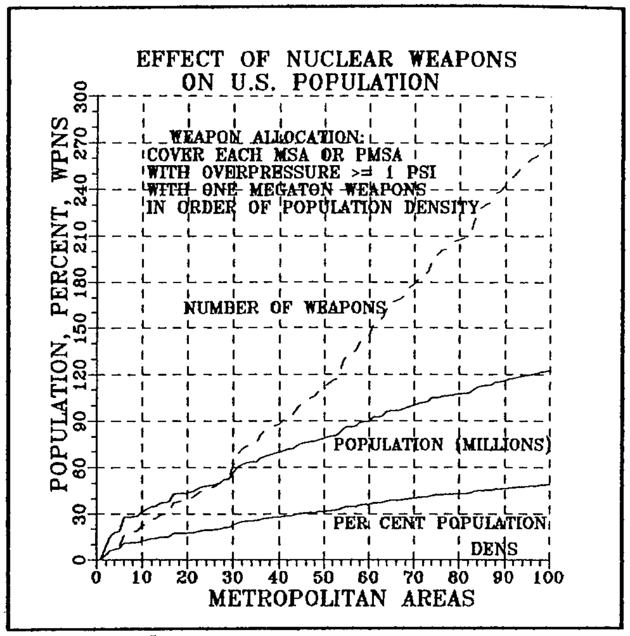

Figure 4

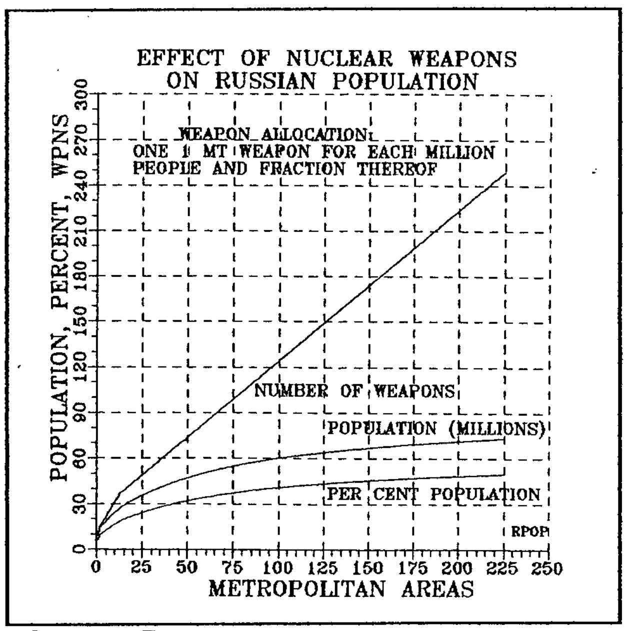

Figure 5

Aspects of First Strike Stability

First strike stability is a more stringent measure of deterrence than central deterrence for several reasons. Central deterrence is a one sided measure. First strike stability is a two-sided measure, and is related more to behavior in a deep crisis.

Central deterrence is based on the idea that an attacker should never conclude that he could avoid a very destructive retaliation. Thus, the decision by the attacker would be not to attack and maintain the status quo, i.e. peace. This measure is one sided in that the alternative to attacking does not involve

an action on the part of the defender, and is not particularly applicable to situations such as instability in a crisis where both sides may be prepared to strike first.

On the other hand, first strike stability is based on the assumption that each side would assess the costs of going first, but the alternative would not be no nuclear exchange. The alternative option under first strike stability would be waiting to endure a strike with nuclear weapons. Thus, the leadership of both countries involved would consider whether or not to strike first or to wait for the other side to strike first with nuclear weapons.

If first strike stability is high (approaching unity), then neither side would be tempted to strike first. Such a condition is met when a substantial fraction of both sides' nuclear inventories are based so that they can survive a first strike. When the first strike stability is low (approaching zero), then one or both sides may be tempted to strike first. Lowering of alert rates for land based weapons, or at-sea rates for sea based weapons, tend to degrade first strike stability.

If either Russia or the U.S. were to deploy an effective nationwide anti-ballistic missile (ABM) defense system, then first strike stability would be degraded as a function of the number of interceptors deployed. The reason for this effect is that the measure of first strike stability captures the concept that one side may decide to go first because it believes it can limit retaliatory damage to its valued infrastructure with an effective ABM system.

The application of the measure of first strike stability illustrates these effects when limits of 2500 or 800 nuclear warheads are considered for further arms reduction environments. Figure 6 shows first strike stability as a function of the number of ABM interceptors on each side for a limit of 2500 similar to the START III accords. Stability is higher for Posture B since more weapons are on alert on both sides and can escape undamaged in a first strike. As the number of ABM interceptors is increased, first strike stability decreases for either posture A or B. If the numerical limits of the ABM Treaty are observed, (100 interceptors) then the amount of degradation seems small. Some analysts or those involved in setting policy may be concerned that the alert rates under posture A may be too low since the first strike stability is half way between zero and unity. If so, somewhat higher alert rates could be needed.

First strike stability under a limit of 800 strategic nuclear warheads for each side is similar to that illustrated for a limit of 2500 warheads. Figure 7 shows these trends, but for lower variations in the deployment of ABM interceptors. Again, some may judge that first strike stability is uncomfortably low

in posture A, and consider somewhat higher rates of alert. One trend evident at the lower levels of warheads is that first strike stability "levels out" when the number of interceptors approaches 400. Some analysts argue that first strike stability would increase as the number of ABM interceptors are increased beyond the values shown in this figure. Such may well be the case as the number of interceptors approaches a condition known as defense dominance. True defense dominance can never be attained with the force mixes considered here. Bombers form one part of the nuclear forces assumed in this analysis. True defense dominance cannot be achieved unless the effectiveness of air defenses can be increased to high levels along with the extensive deployment of ABM capabilities on both sides.

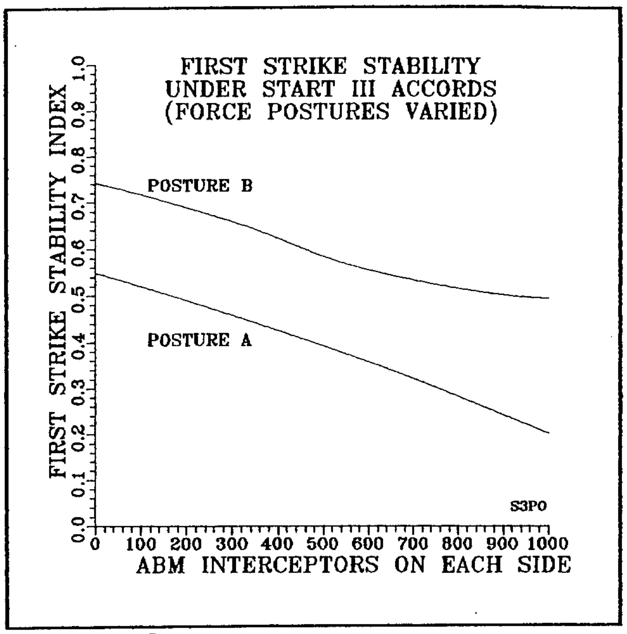

Figure 6

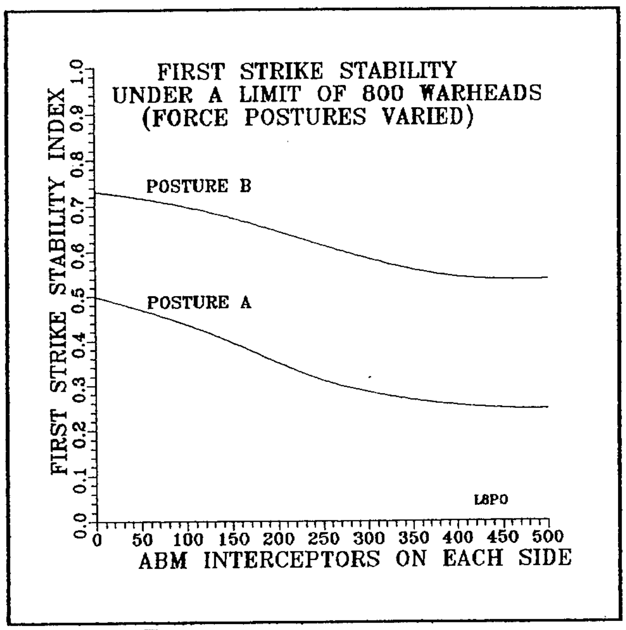

Figure 7

Examination of one aspect of assured destruction and first strike stability in this chapter force us to conclude that the essential elements of deterrence would probably remain for both the U.S. and Russia under reduced levels of nuclear warheads. First strike stability under the degree of alert currently in effect could be worrisome to some decision makers. Small ABM systems meant to protect either the U.S. or Russia against small attacks by other countries could be accomodated without serious degradation of first strike stability between the two principals. Deployment of national defenses would need to be discussed and agreement reached between the two nations in this matter.

V - CONSIDERATIONS OF LAUNCH ON WARNING

The potential tactics "launch on warning" or "launch under attack" have been considered by many analysts and decision makers since the dawn of the nuclear age. In this chapter, the emphasis will be placed on the tactic of launch on warning. Until recently, the U.S. public policy on launch on warning has always been vague, indicating to a potential attacker that he might face such a response, or that he might not. Motivation for considering such a doctrine, its feasibility, and the author's comments are offered in this chapter.

Motivation for Launch on Warning

The basic motivation on the part of some military and political strategists has been the possibility of using nuclear warheads before they were destroyed by an enemy attack. The resulting employment of this tactic was essentially a step to increase strategic weapon survivability. Such a tactic has been employed for the bomber force. Some bombers are placed on "strip alert" so they might escape out from under a nuclear attack. Bombers can be recalled if the warning signals and messages later were deemed to be erroneous.

With regard to intercontinental ballistic missiles (ICBMs), there has always been some concern over their potential vulnerability, particularly those housed in underground silos. During the 1980's, these concerns grew dramatically and were often expressed in the form of the term, "window of vulnerability." At that time, the former Soviet Union possessed over 300 SS-18 ICBMs each armed with 10 re-entry vehicles. Intelligence estimates of the accuracy of Soviet ICBMs combined with the range of uncertainties in the hardness of U.S. silos resulted in a genuine concern about the survivability of the U.S. ICBM force based in Minuteman silos. The ICBMs, both Minuteman and Peace Keeper, could be considered high value targets to an attacker because they carried multiple warheads, three for Minuteman, and ten for the Peace Keeper. A numerical definition of the window of vulnerability is illustrated in Table 4. In this table, the hardness is one factor, and the CEP (probable circular error) of attacking warheads is another factor. Minuteman silos were designed to withstand overpressures of 2000 psi [12], but might withstand as much as 4000 psi in an optimistic view. The probable errors of the Soviet delivery systems were assumed to be between 300 and 600 ft. Under these assumptions, the window of vulnerability is bounded. These bounds are outlined in the table. In the worst case, the probability of crushing a silo due to blast overpressure is 0.99 and in the most optimistic corner, about 0.68. If the Soviets were to target two warheads on these targets, then the probability of survival of the Minuteman silos would range between 0.000049 and 0.103. Under a tactic of launch on warning,

the survivability of a missile is equal to its availability rate for launching, or about 0.9 instead of 0.1 or less.

Table 4 - Window of Vulnerability

CEP VARIATIONS FOR YIELD OF 500 KILOTONS

	OVERPRESSURE (PSI)						P(CRATER)	
CEP(FT)	500	1000	2000	4000	7000	10000	SOIL	ROCK
100	1.000	1.000	1.000	1.000	1.000	1.000	0.997	0.988
150	1.000	1.000	1.000	1.000	0.998	0.997	0.968	0.915
200	1.000	1.000	0.999	0.997	0.991	0.981	0.890	0.782
250	1.000	1.000	0.998	0.990	0.969	0.944	0.779	0.639
300	1.000	0.998	0.993	0.972	0.929	0.884	0.663	0.516
350	0.999	0.996	0.983	0.942	0.872	0.809	0.559	0.418
400	0.998	0.991	0.966	0.900	0.806	0.730	0.471	0.342
450	0.996	0.983	0.941	0.849	0.736	0.652	0.399	0.283
500	0.992	0.970	0.909	0.793	0.667	0.581	0.340	0.237
550	0.987	0.952	0.871	0.736	0.603	0.517	0.292	0.201
600	0.979	0.930	0.829	0.679	0.544	0.461	0.253	0.173
650	0.968	0.904	0.785	0.626	0.491	0.411	0.220	0.149
700	0.954	0.874	0.740	0.575	0.444	0.368	0.194	0.130

Figure 8 presents a graphical view of the window of vulnerability. The two curved and dashed lines correspond to silos that can withstand 2000 and 4000 psi overpressures. For CEPs between 300 and 600 ft, attention is focussed on the upper left portion of the figure where probabilities of damage are quite high. The horizontal dashed line indicates the value used in earlier analyses of first strike survivability. This value is further modified by the combined probability of launch availability and in-flight reliability (0.8) for a total probability of kill of about 0.6.

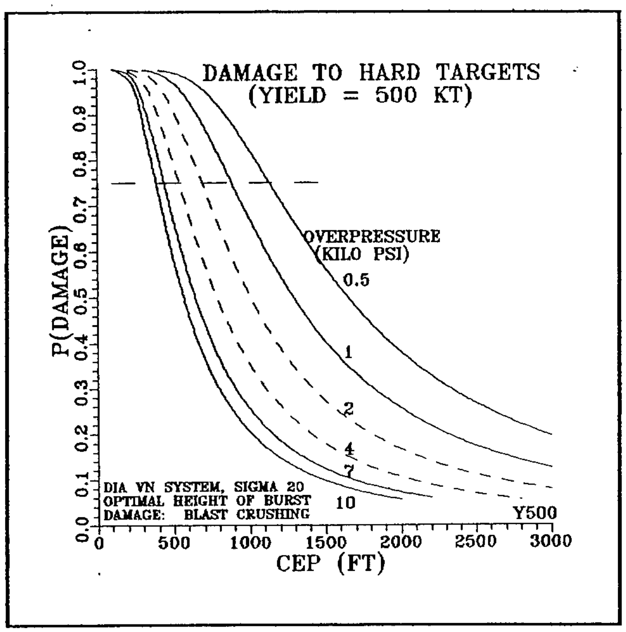

Figure 8

Overall, the number of ICBMs launched out of a force of 1000 missiles after an attack would be on the order of zero to 100, but would be about 900 if the launch on warning tactic were to be employed. These estimates overlook some important aspects such

as the implication of a false warning message, and secondarily the timing of the arrival of U.S. warheads, and other constraints that normally would be in effect in an operational war plan.

Another motivation for implementing a launch on warning tactic could be that first strike stability would be increased in many situations. This trend resulted because the apparent vulnerability of U.S. ICBMs would be "solved" through a very quick launch of that force.

Launch on Warning and First Strike Stability

This section provides an examination of the effect of launch on warning on first strike stability. Launch on warning is sometimes mentioned as a factor in creating instability. As we shall see, this is not the case with regard to first strike stability **when it is assumed that launch on warning is feasible.**

The analysis of first strike stability of a previous chapter is used as the basis for further elaboration to consider launch on warning. As before, first strike stability is considered for two levels of nuclear arsenals on each side (2500 and 800 warheads) and the number of ABM interceptors deployed by both sides. The force structures involved are the same as in previous analyses in this report, and the forces are assumed to be in posture A (no bombers and none or few mobile ICBMs on alert). To examine first strike stability, it has been assumed that <u>all ICBMs and all SLBMs</u> in port could be launched on warning of an attack. Some analysts may argue with this assumption, but it is brought into play here to examine a worst case situation. Further, it will be assumed 1) that there will be no launch on warning (LOW), 2) that the U.S. could launch on warning, 3) that the Russians could launch on warning, and finally, 4) that both sides could be capable of launching on warning.

Under the assumed force structures under START III, Figure 9 shows first strike stability as a function of the number of ABM interceptors deployed by each side. Without launch on warning, the results are identical to a previous figure. If the U.S. were to launch on warning of a Russian attack, there would be some minor improvement in first strike stability. On the other hand, if the Russians were to launch on warning of a U.S. attack, there would be a substantial improvement of first strike stability. One reason for the difference in the effect lies in the assumptions concerning the at-sea rates of submarines for both sides. On the U.S. side, 2/3 of the submarines are assumed to be at sea and would provide a nearly invulnerable force. On the Russian side, about 30% of their submarines were assumed to be at sea. Under a launch on warning tactic, all of the SLBMs in port would be launched. These in-port missiles would be very vulnerable if they were not launched on warning. Under launch on warning, 90% (the assumed launch readiness rate) of them are

launched at American targets. A similar situation would apply to the Russian mobile ICBMs. All mobile RS-12 ICBMs were assumed to be in their garrisons where they would be very vulnerable to attack. With a single American warhead aimed at each garrison, about 20% of these ICBMs would be expected to survive. With two American warheads aimed at each garrison, about 4% would be expected to survive. With launch on warning, 90% of the mobile RS-12 ICBMs would be launched before American warheads would impact on Russia.

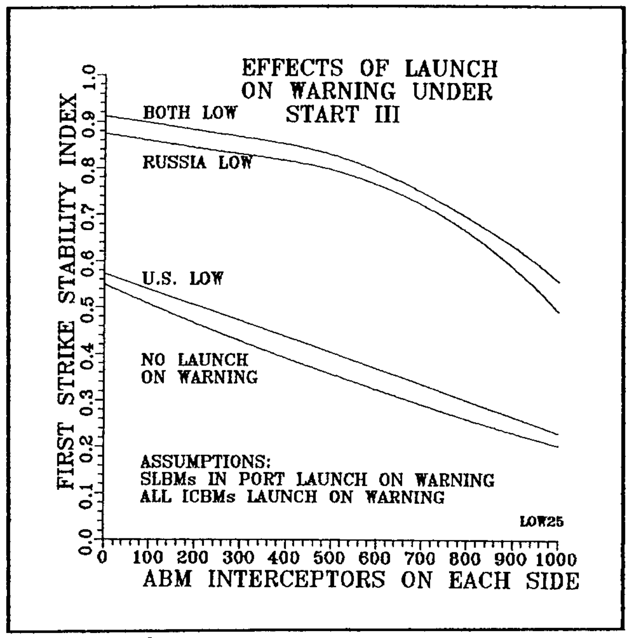

Figure 9

If it is assumed that both the Russian and American inventories of strategic nuclear weapons are limited to 800 warheads, then a somewhat different outcome prevails. Under these assumptions, however, launch on warning implementation does increase first strike stability as shown in Figure 10. If the U.S. launches on warning, then a somewhat greater increase in first strike stability results compared to the previous situation under START III. If Russia were to launch on warning, then an appreciably larger increase in first strike stability would ensue. When it is assumed that both sides could launch on warning of an attack, then the first strike stability is extremely high with no ABM deployed.

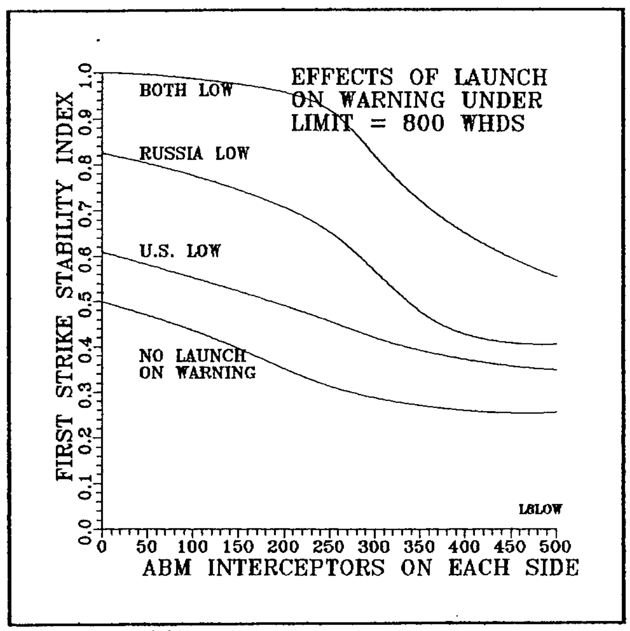

Figure 10

The addition of ABM interceptors degrades first strike stability in all cases, but does so markedly for launch on warning situations if 250 or more interceptors are deployed. When 500 ABM interceptors are deployed, their numbers approach the number of RVs that either side could muster in a retaliatory

attack. In this case, ABM interceptors bring each side nearer to a defense dominant condition. Complete defense dominance cannot be achieved because both sides have bombers, and the defenses against such aircraft are assumed to be quite low (about 80% of the bombers on each side are assumed to penetrate air defenses). On the U.S. side, the ICBM force is small (48 RVs), and the U.S. submarine force is largely at sea. Further, the B-2 bombers constitute a substantial fraction (40%) of the total strategic nuclear force. With regard to the Russians, their strategic nuclear force is dominated by ballistic missiles. Their bomber force contains about 15% of the total.

Feasibility of Launch on Warning

Regarding the feasibility of implementing a launch on warning tactic, two important questions must be addressed. How confident can we be that an attack is underway? Is there enough time available to implement launch on warning? The first question will be addressed by examining the effectiveness of warning systems and commanders in assessing the probability that an attack is underway using extensions to Bayesian statistics. The second question will be addressed by bounding the time available to make decisions and send out launch orders.

How confident can we be that an attack is underway, given that warning messages are being issued? One approach is to apply Bayesian methods to this problem [13]. Under this approach, the analyst can examine the expectations of an attack under a variety of assumptions.

Warning Messages and Confidence Levels

In this analysis, our assumptions are made to address two fundamentally different conditions: an "ideal" situation, and a "more realistic" situation. In the "ideal" case, it is assumed that every message indicates that an attack is underway. For the "more realistic" case, it will be assumed that some messages will be generated indicating that no attack is underway when the converse is true. For both sets of assumptions, the probability of warning given an attack will be varied.

The first example of this approach under so called ideal conditions is shown in Figure 11. In this example, the warning system is assumed to function extremely well. It is assumed that the probability of warning given an attack is 0.95, and that the probability of warning given no attack is quite low, 0.05. The other important input to the process is the predisposition of a commander as to the liklihood of an attack at a particular time. The commander is assumed to base his opinion on the political conditions, his assessment of the attacker's motivation at that particular time, and the degree of caution or risk averseness. Other factors may enter into establishing this predisposition as

well. Thus, this *a priori* condition is varied between 0.1 and 0.7. Under these assumptions, the somewhat cautious commander would have a high confidence that an attack was underway after receiving three warning reports. Conversely, the commander who felt that an initial probability of an attack was 0.7 would be convinced that an attack was in progress after the receipt of two warning reports. The frequency of the receipt of such messages will be important later in this analysis.

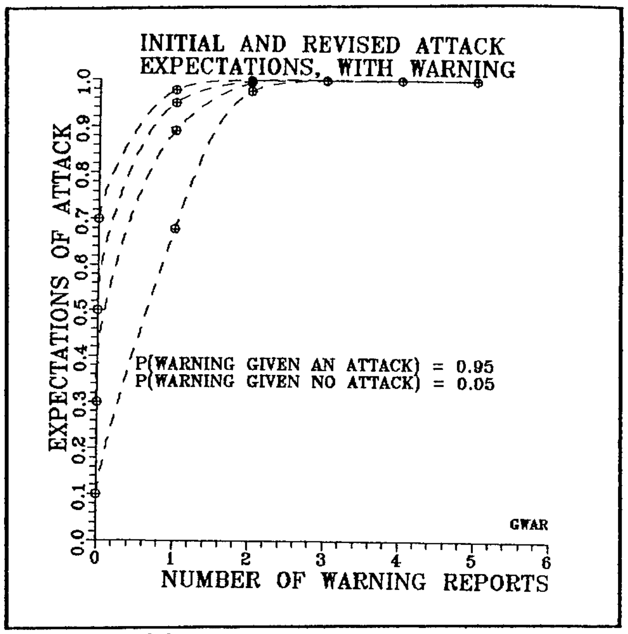

Figure 11

A second example of warning and expectations of attack under so-called ideal conditions is based on the assumption that the warning system may not be working as well as could be desired by its designers. For this example, it is assumed that the probability of warning given an attack is 0.7 (not 0.95), and that the probability of no warning given that there is an attack is 0.3. These assumptions tend to give less credit to meeting the design objectives of the warning system, and may reflect uncertainties that may not be resolved by testing the system in command exercises. These assumptions are embodied in the results illustrated in Figure 12. If the commander is predisposed to assign a low probability of attack at a particular time, say 0.05, then at least 9 warning reports will be needed to convince him with high confidence that an attack is underway. The more hawkish commander may be predisposed to believe that the liklihood of an attack is 0.9. Under these conditions, even the hawkish commander will need to receive at least four warning reports to achieve high confidence that an attack is underway.

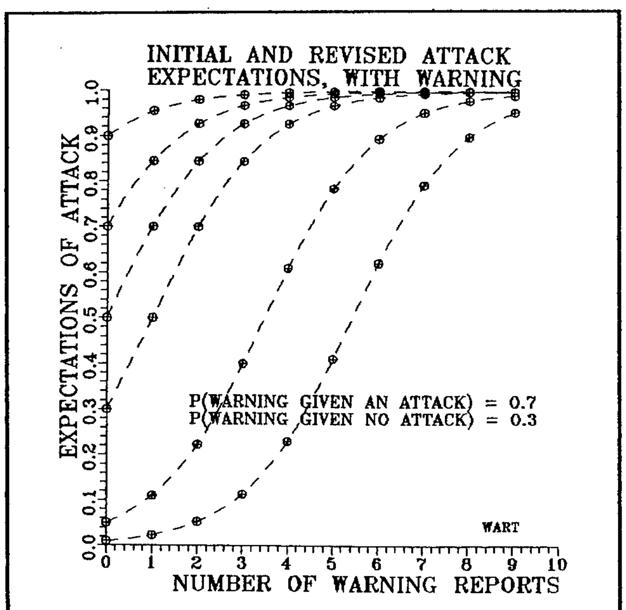

Figure 12

The differences in these examples represent attempts to capture some of the variations that may apply to the launch on warning problem under "ideal" conditions. In the worst case assumed here, at least nine warning reports would be needed to establish the very high confidence needed to order a launch on warning. At the very best in the examples offered here, about three to four reports would be needed, if the warning system is operating with good efficiency under so-called ideal conditions, i.e. every warning report indicates that an attack is underway when, in fact, it is. In what follows, we introduce a variation to this "ideal" set of assumptions.

In a "more realistic" analysis of the generation of messages indicating that an attack is underway, it would be expected that there would be messages indicating that no attack was underway. To extend the analysis to include the effect of false messages that no attack is underway, even when the converse is true, a Monte Carlo technique is employed. Using this approach, a message indicating that no attack is underway (even when it is) is generated when a random draw is less than some expected error rate. In this instance, we assume that the threshhold is the non-detection of an attack. The non-detection threshhold is set at 0.3 to show the effects on the number of messages needed to assure high confidence that an attack is underway for comparison with the previous results based on "ideal" assumptions. Thus, in this analysis both of the previous equations in Chapter II (equations 6 and 7) come into play. Under the random draw of a fraction, if the fraction is 0.3 or less, a message indicating that no attack is underway will be generated. If the random fraction is greater than 0.3, a message will be generated indicating that an attack is underway. The results of the analysis will be based on 100 Monte Carlo runs.

The first example under the "more realistic" conditions is based on the assumption that a commander is predisposed to the probability of an attack is 0.5. On the average, it would take about 30 messages to assure high confidence (0.99 or more) that an attack really is imminent rather than the six messages (see Figure 12) resulting from the analysis under "ideal" assumptions. In simulations involving random draws, there may be streaks of good or bad luck. The generation of warning that an attack involving nuclear weapons is underway may not be a common occurence. Thus, 100 trials may not be an appropriate value to assure decision makers of what might happen at sporadic times when an attack is suspected. Streaks of good and bad luck may seem extreme, but they are possible within the statistical bounds of this analysis. Figure 13 indicates both extremes for this particular example. The best case of 100 runs results when every message generated indicates that an attack is underway, and is in agreement with previous results expected under "ideal" conditions. On the other hand, the dashed line shows an extreme result in the other direction. The first message causes the

commander to increase his expectation of an attack, but the mixture of attack and no-attack messages that follow illustrate the effect of a streak of bad luck. The attack expectation in this streat of bad luck never exceeded 0.99 even when 40 messages were generated.

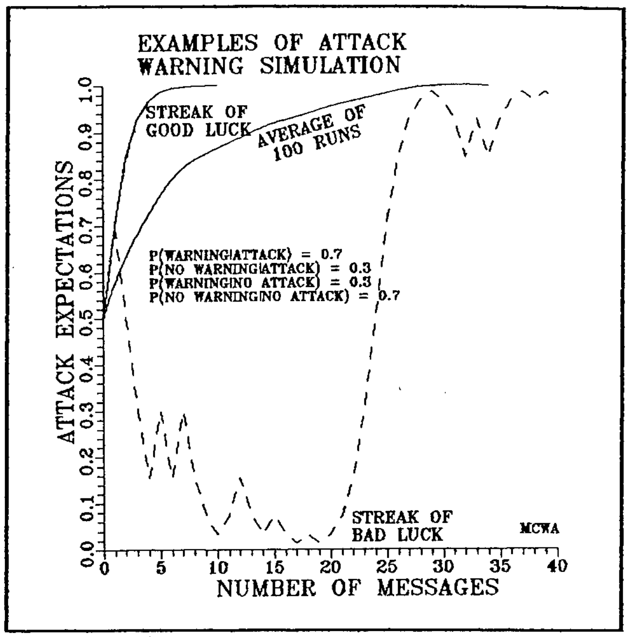

Figure 13

The next example of the Monte Carlo simulation results is based on the assumption that a commander is predisposed to believe that the probability of an attack is low, 0.05. Under this assumed predisposition, the average of 100 runs indicates that receipt of 40 messages will not result in an attack expectation of 0.99 or greater. Figure 14 indicates this average along with streaks of good and bad luck. The streak of good luck is based on one run where successive messages were error free at first, but followed by a few messages indicating that no attack was underway. There is a slight wavering of confidence when ten messages have been received. The curve corresponding to the streak of bad luck indicates what the author believes to be the worst case of the 100 runs. Even after the receipt of 40 messages, the expectation of attack never exceeds 0.8. The risk that such a string of messages could occur may tend to discourage high level decision makers whether or not they are considering the implementation of launch on warning.

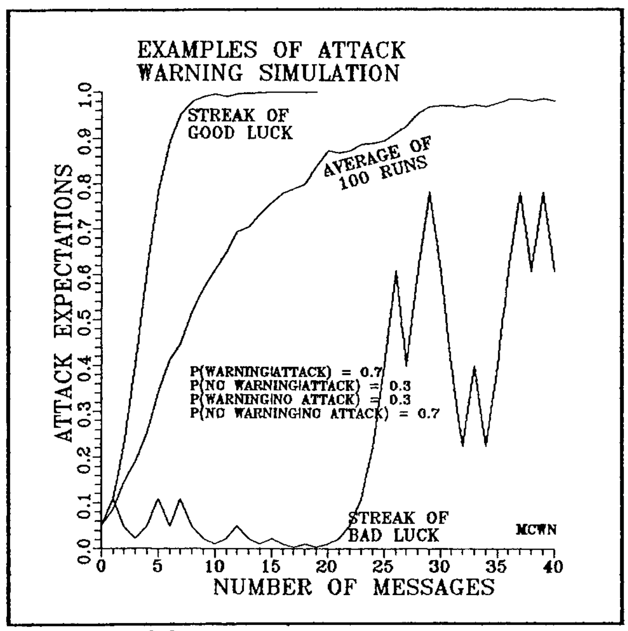

Figure 14

Some readers may object that a non-detection rate of 0.30 may be too severe, and insist that a lower probability of non-detection of an attack would be appropriate. The following example is based on the assumption that the probability of no warning given an attack is 0.05, and that the probability of

warning given an attack is 0.95. Figure 15 displays the results of the simulation (100 runs) showing the average, the worst and the best results. For this simulation, the average number of messages needed to assure an attack expectation in excess of 0.99 is 6, twice the number needed under "ideal" conditions. With bad luck, seven messages would need to be received to meet the same criterion. This criterion is arbitrary, and translated into lay terms would correspond to a chance of 1 in 100 of societal obliteration. For some decision makers, such odds may not be acceptable.

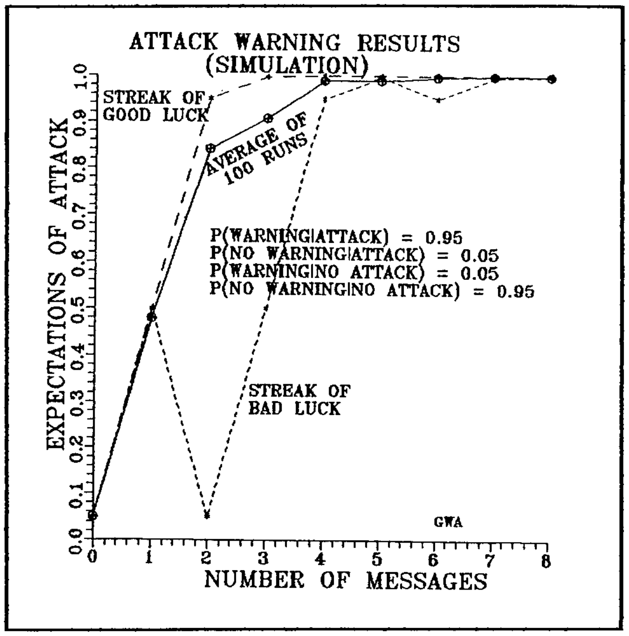

Figure 15

Several important parameters are not considered in the analyses of this type. No consideration is given to the effect of reports based on multiple phenomenologies (radar, infrared, visible light, seismic, or other sensors). No consideration is given to the number of warheads in the assumed attack. These parameters contribute to the validity and reliability of the outputs of any warning system. Unreliability in sensors may have an effect on the efficiency of the warning system. The size of a supposed attack could have an enormous impact on the reaction of a commander. Is only one missile involved, or are there 100 MIRVed missiles approaching? Thus, the above analysis should be considered as scratching the surface of the problem. On the other hand, no matter how many tests are conducted and how much confidence is placed on the design of a warning system, we may never really know or appreciate how good or bad its performance may be. Command exercises, no matter how carefully designed, may not uncover flaws in the total warning system.

Determining the time available to implement the launch on warning tactic is needed to assess its feasibility. In performing this assessment, the analysis will focus on Russian warning devices. If the Russians were to worry about U.S. ICBM attacks, they would need to rely on their space based launch detection system. The time available for a launch on warning decision would be the flight time of the ICBM, about 30 minutes or so. Shorter times would be involved if the first round of an attack were initiated by sea launched ballistic missiles. Some have suggested that the Russians might have a space based system that would observe the launch of these missiles [14]. If so, the time available would be on the order of the SLBM flight time. In

the worst case, SLBMs could be observed only by the Russian early warning radar system.

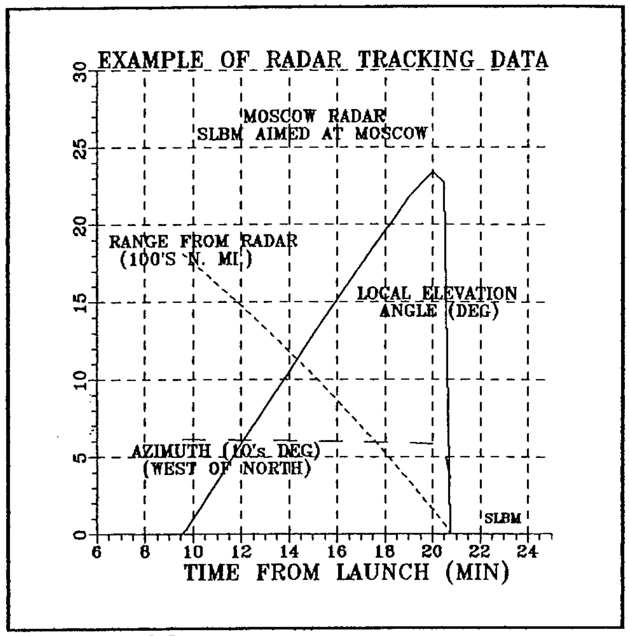

Figure 16

Severe timing constraints would prevail if the Russians were expecting an attack employing SLBMs launched off the coast of Newfoundland and aimed at Moscow. The Russians might have only their radars to detect such an attack. Figure 16 indicates the radar parameters, range, elevation, and azimuth, of the flight path of the warheads involved. From this figure, approximately 9 minutes would be available (at most) for a decision to launch on warning, if all of the Russian ICBMs and in-port SLBMs were at their highest readiness condition, and local commanders were assumed to be able to execute a launch order instantaneously. Such assumptions may not be realistic. A warning report might not be generated at the first detection of the warheads. Time would be needed to assemble the requisite data. ICBMs ordered to launch in a prompt manner may not be ready to do so. The time taken to reach a high confidence level that an attack is underway may be longer than expected. Other factors not considered here may also interfere with the implementation of launch on warning, such as weapon arrival timing, avoidance of fratricide, and limiting the number of silo doors that are open at any given moment.

One incident directly involving Russian reaction to the detection of a potential attack has been described [15]. The incident involved the launch of a sounding rocket from Andoya, an island just off the northern Norweigian coastline. Russian sensors did detect the event. High level decisionmakers were assembled and discussed the consequences of reacting to a supposed attack or not reacting. In the end, no Russian missiles were launched. The overall warning system may not have worked as planned, but the system involving high level decision makers did work successfully. One Russian problem appeared to be that they were not aware of a message that such an operation was to take place. The message reportedly did not reach the higher levels of command. Thus, we conclude that the Russian system probably was tested under realistic conditions, and portions of the overall system were found wanting. Luckily, or because hasty decisions were avoided, or because Russian leaders were predisposed to

believe that the U.S. would not attack, the outcome of the affair ended without involvement in nuclear combat.

Overall Comments on Launch on Warning

In this chapter, several topics have been examined with relation to a launch on warning tactic. Our observations are reviewed at this point.

The motivation for launch on warning as a tactic is essentially based on the old phrase, "Use it or loose it." The underlying reason for supporting this tactic has been the assumed vulnerability of American silos, but Russian silos also might be quite vulnerable, even if it is assumed that they are much harder than the American silos. The so-called window of vulnerability illustrated in this chapter underlies these concerns.

With regard to feasibility, it may not be possible to confidently rely on a launch on warning tactic. Under the worst case, an attack by a sea-launched ballistic missile, the time of flight of such a missile is short. In the calculations presented here, about 8 to 10 minutes might form the timeframe for a launch on warning to be implemented. As was shown, anywhere from about 6 to 40 or so messages warning of an attack might be needed to assure a high confidence that an attack was underway under the assumption of a degraded warning system and a commander's low disposition to assume that an attack were probable. If the frequency of warning messages were high, about one every 30 seconds, then launch on warning might be feasible if 6 to 10 messages were involved under "ideal" conditions. Under "more realistic" conditions thirty or so messages might be needed to assure high confidence that an attack was underway. Under these assumptions, then implementation of launch on warning would not seem feasible. If the interval between warning messages generated on the basis of various sensors were longer, then the feasibility of launch on warning would be tenuous even under the most favorable assumptions. Other factors also must be considered. These would include the timing of the launch response (the length of time needed to launch a appreciable fraction of the ICBM force), and the state of alert of the missiles involved in such a launch. All of these factors are uncertain, particularly in the case of a Russian response. One other factor, not considered here, is the reaction of the head of state, either in the U.S. or Russia, and the timing of his decision. Overall, our assessment is that launch on warning seems easy, cheap, and neat, but extremely dangerous on all of the counts just mentioned.

The implementation of a tactic of launch on warning would increase first strike stability. This trend arises because launch on warning would essentially increase the survivability of

the ICBMs and the SLBMs remaining in port. The dangers may far outweigh the advantages of such a tactic.

Finally, the current policy of the United States is NOT to launch on warning. In the past, the launch on warning policy has been somewhat vague, thus indicating to the former Soviet Union that it might or might not face a launch on warning response if it chose to strike first. More recently, however, Robert Bell [16] made the following statement in discussing a recent Presidential Decision Directive (PDD-60, November, 1997).

"With respect to strategic nuclear deterrence, the PDD reaffirms our fundamental committment to maintain a strategic nuclear posture across a triad of strategic forces, a robust posture that is not dependent on a launch-on-warning planning assumption, and that includes secure reserve forces and survivability sufficient to allow you to confirm that a nuclear weapon has actually detonated on American soil before you would have to face the retaliatory decision."

With regard to the Russians, the only available experience concerning launch on warning has been positive. When an unexpected launch occurred near the Norweigian coast, high level decisionmakers did not order their forces to launch in retaliation. Whether or not such a positive action on their part would be taken in the future remains quite uncertain.

VI - "BREAKING OUT" OF TREATY AGREEMENTS

In the defense and arms control community, there is always a worry about the consequences of a sudden abrogation of an arms control agreement. In this chapter, we examine several possibilities of such events. If there is a breakout, the concern is usually that the number of warheads can be increased dramatically. It is often feared that such increases in armament will result in one side suddenly becoming dominant, and that any form of stability would be upset. In this chapter, it will be assumed that the number of weapon delivery systems remains constant when one or both sides break out of an agreement. It is assumed that only the number of warheads carried by ICBMs or SLBMs will be increased. This assumption seems consistent with the possibility of cheating if an overall accord on inspection and verification were less than complete and thorough. In this examination, the two levels of nuclear weapon arsenals used earlier will be addressed: 2500 and 800 warheads possessed by each side.

Assumptions Concerning Forces

For the purposes of this analysis, it is assumed that the number of warheads carried by ICBMs and SLBMs could be increased. The number of warheads carried by bombers is assumed not to change if one side or both were to break out from an agreement.

Under the assumptions made earlier in this report, land based ICBMs were limited to one warhead apiece. SLBMs carried an agreed to number of RVs. The incremental changes assumed for the analysis of breakout are displayed in Table 5. In this table, the increased payloads of ballistic missiles are shown under the START III accords and for a lower limit of 800 warheads.

The assumptions behind each of the increases in the number of re-entry vehicles (RVs) is based on reports or initial design objectives. The Minuteman ICBM carried three RVs in a MIRVed configuration. Under START II each Minuteman would carry a single RV. The Trident SLBM could carry as many as 12 or 14 RVs, but at a reduced range capability. On the Russian side, the RS-18 ICBM carried six RVs, but under START II all land based ICBMs would be limited to a single RV. One test of the RS-12 ICBM was conducted when it was equipped with 4 RVs [12]. The Delfin SLBM was initially designed to accomodate 10 RVs, but later the payload was reduced [12]. The bombers on both sides are assumed to carry the same payload, even under breakout conditions.

Table 5 - Incremental Warhead Increases for Breakout

System	RVs per Ballistic Missile No Breakout	Breakout
United States, START III		
Minuteman	1 RV/ICBM	3 RV/ICBM
Trident	4 RV/SLBM	12 RV/ICBM
Total Warheads	2500	5780
Russia, START III		
RS-18	1 RV/ICBM	6 RV/ICBM
RS-12	1 RV/ICBM	4 RV/ICBM
Typhoon	8 RV/SLBM	10 RV/SLBM
Delfin	4 RV/SLBM	10 RV/SLBM
Total Warheads	2500	5434
United Sates, Limit = 800		
Minuteman	1 RV/ICBM	3 RV/ICBM
Trident	2 RV/SLBM	8 RV/SLBM
Total Warheads	800	2192
Russia, Limit = 800		
RS-12	1 RV/ICBM	4 RV/ICBM
Delfin	4 RV/SLBM	10 RV/SLBM
Total Warheads	800	2360

If such incremental changes were to occur, the number of nuclear warheads on either side would more than double. Such a suddenly emerging threat could be of great concern to both political decision makers and military strategists, if they were aware of such changes.

The actual assumed force structures if either the U.S. or Russia were to "break out" of the START III accords, and an assumed limit of 800 warheads for each side are shown in Tables 6 and 7. These tables give the accounting for both sides. These tables show the assumptions that enter into the analyses of cheating or breakout.

Table 6 - Assumed Breakout Forces, START III

System	Loading	Warheads
United States		
Minuteman	488 ICBMs, 3 RV/ICBM	1464
Trident	12 SSBN, 24 SLBM/SSBN, 12 RV/SLBM	3456
B-52	27 AC, 20 Whds/AC	540
B-2	20 AC, 16 Whds/AC	320
	Total Warheads 5780	
Russia		
RS-18 (Silo)	105 ICBMs, 6 RV/ICBM	630
RS-12 (Mobile)	360 ICBMs, 4 RV/ICBM	1440
RS-12 (Silo)	139 ICBMs, 4 RV/ICBM	556
Typhoon	6 SSBN, 20 SLBM/SSBN, 10 RV/SLBM	1200
Delfin	7 SSBN, 16 SLBM/SSBH, 10 RV/SLBM	1120
TU-95	23 AC, 16 Whds/AC	368
TU-160	10 AC, 12 Whds/AC	120
	Total Warheads 5434	

Table 7 - Assumed Breakout Forces, Limit = 800

System	Loading	Warheads
United States		
Minuteman	48 ICBM, 3 RV/ICBM	144
Trident	9 SSBN, 13 SLBM/SSBN, 8 RV/SLBM	1728
B-2	20 AC, 16 Whds/AC	320
	Total Warheads 2192	
Russia		
RS-12 Mobile	360 ICBM, 4 RV/ICBM	1440
Delfin	5 SSBN, 16 SLBM/SSBN, 10 RV/SLBM	800
TU-160	10 AC, 12 Whds/AC	120
	Total Warheads 2360	

Damage Levels When Russia Strikes First

Damage to the U.S. is employed as a measure to examine cases where Russia might break out of an arms control accord. This measure is the fraction of value damaged should Russia break out and strike first. This measure is purely one-sided, but shows the implications of breakout in stark terms. Again, limits of 2500 and 800 warheads are the subjects of the analyses.

If Russia were to break out of the START III accords and strike first, then the damage inflicted on the U.S. would increase, while the damage to Russia would decrease. Major assumptions are that Russia would strike first, and further, that Russia would allocate its strategic nuclear warheads to minimize

overall cost, as defined in the methodology describing first strike stability. Figure 17 indicates these effects. It is the increase in damage to the U.S. accompanied by a decrease in damage to Russia that could be alarming to U.S. defense analysts, assuming that intelligence resources indicated such an action.

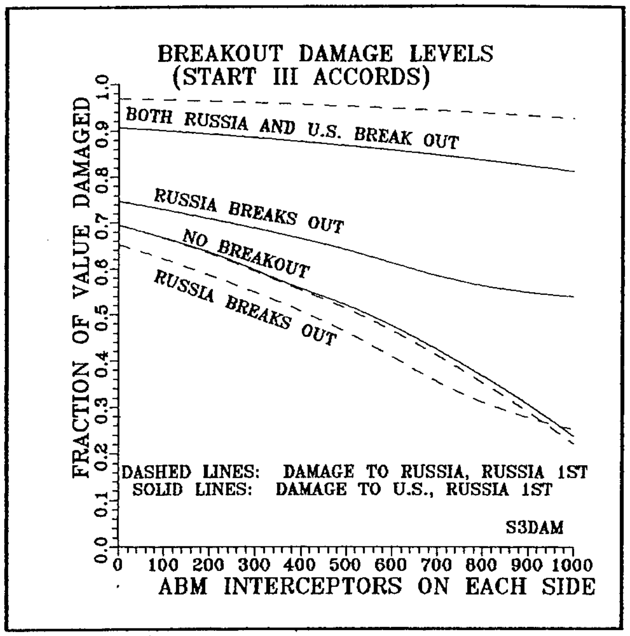

Figure 17

If the U.S. were to discover that the Russians were breaking out from START III and decided to break out as well, then the top lines in the figure indicate that both sides could suffer extremely high damage if Russia were to strike first. The level of nuclear warheads possessed by both sides under the assumptions of this analysis would correspond to the results of a race to increase the strategic nuclear warheads on both sides.

If the warheads on both sides were limited to 800 on both sides, a Russian breakout could be even more alarming than at the START III levels just discussed. The difference would be that a Russian breakout would cause little change in the fraction of value damaged by a U.S. retaliatory strike, but the damage to the valued assets of the U.S. would increase dramatically. Some analysts might interpret these changes as a shift from parity in nuclear weapons (no breakout) to Russian superiority. If Russia were to strike first, then the damage to the U.S. could increase from 0.3 or 0.4 to about 0.7 or more depending on the number of ABM interceptors deployed. These trends are illustrated in Figure 18. If the U.S. were to detect Russian activities and decided to follow suite, then the level of damage to both the U.S. and Russia would be very high. The number of

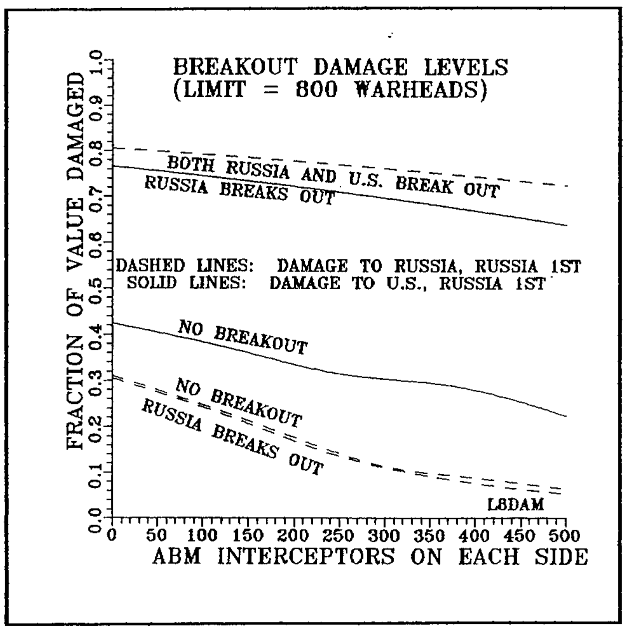

Figure 18

weapons on both sides would be quite similar to the START III accords. Although increases from 800 warheads on each side to more than 2000 warheads would constitute an alarming increase by many analysts and decisionmakers, it will be shown that first strike stability would not necessarily be degraded. Rather, first strike stability would increase because neither side would wish to risk the levels of damage just indicated.

First Strike Stability Estimates with Breakout

In this section, first strike stability will be considered for conditions of no breakout and with breakout from START III and a limit of 800 warheads on each side.

If Russia were to break out of the START III accords by uploading ICBMs and SLBMs, then Russia would create considerably more firepower than the U.S. Additionally, Russia would also have many more RVs in a much more survivable condition - more warheads would be at sea. Under these conditions, Russia could inflict much more damage on the valued assets of the U.S., either in a first strike or in a retaliatory strike. The number of warheads involved in a Russian retaliation would be large enough to compensate for the low at-sea rate of submarines assumed earlier. For these reasons, first strike stability would be increased, as illustrated in Figure 19. Under these circumstances, the U.S. would be less tempted to strike first than if no breakout ocurred. If the U.S. detected a Russian breakout and responded in kind, then both sides would have more nearly equal firepower. When both sides break out, the lower Russian at-sea rate for submarines comes back into play, and the U.S. would have far more firepower at sea, and thus have more survivable warheads. Then, the U.S. might be tempted to strike first as under the conditions of no breakout. In all of the cases considered in this figure, first strike stability would degrade as a function of increasing the number of ABM interceptors on both sides. With a limited ABM deployment, 100 interceptors or less, the degradation in first strike stability would be small.

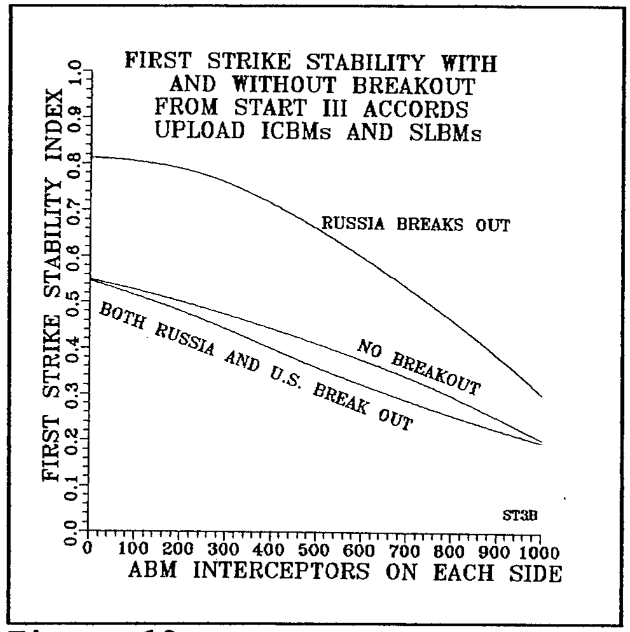

Figure 19

If both the U.S. and Russia were limited to 800 warheads each, then breaking out from this limit has a somewhat different effect than shown above. With a Russian breakout, first strike stability is increased by a very small amount. The reason for this condition lies in the assumptions concerning the alert rate of Russian ICBMs and at-sea rate of Russian submarines. At the lower limit on warheads of 800 on each side, these alert rates were assumed to be higher than under the START III accords.

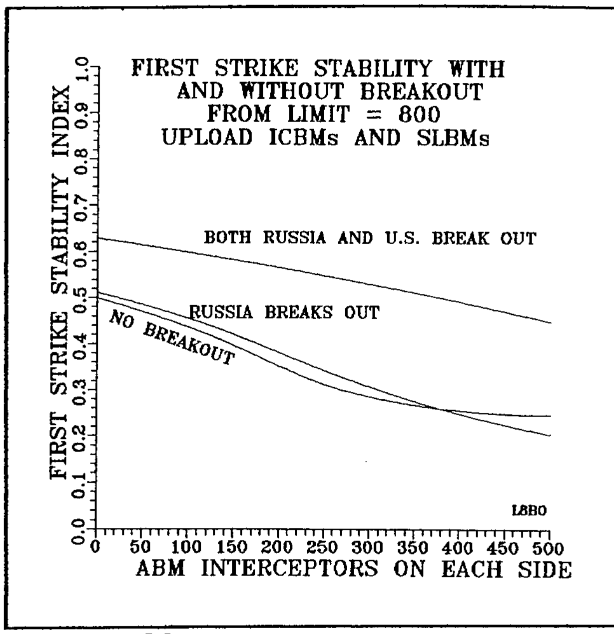

Figure 20

When both Russia and the U.S. break out from a limit of 800 warheads each, then the firepower on both sides is more nearly equal. The U.S. then has a considerable number of warheads at sea in a survivable status, and the first strike stability is higher compared to the no breakout conditions, as illustrated in Figure 20.

Some readers may find that the improvement in first strike stability resulting from breakout by the Russians or both the Russians and the U.S. is counter-intuitive. A higher value of first strike stability is directly a result of higher costs or potential damage suffered by one or both sides. Thus, when first strike stability is high, both sides wish to avoid nuclear conflict because of the high level of damage that they may suffer by either side striking first. While it may appear that breakout may not be of great consequence or that conditions might actually improve, such may not be the case if high damage levels are considered instead of first strike stability. The goal of the arms control and defense communities should be to assure a high level of confidence that breakout would be detected before it reaches a significant level. Measures that might improve first strike stability such as higher alert rates or at-sea rates should be made more attractive compared to the possible uploading of ballistic missiles. Confidence building measures should become an integral part of future agreements so that each side could indicate that higher alert rates are being implemented not to mount a first strike, but to maintain first strike stability, a matter of concern to all involved. Two way communication and cooperation between the U.S. and Russia may provide elements of future confidence building measures.

SUMMARY AND OBSERVATIONS

The purpose of this report has been to examine some of the risks that might evolve at levels of strategic nuclear warheads less than those under the START II Treaty. The risks considered here are 1) a possible loss of deterrence between the U.S. and Russia, 2) the implications of launch on warning responses to first strikes, and 3) the potential consequences of one side, Russia initially, abrogating or cheating under the terms of future arms control agreements. We have examined only two different levels of strategic nuclear inventories: 2500 and 800 warheads on each side.

Deterrence

The effect on deterrence was analyzed using two different methods: central deterrence (a one-sided measure) and first strike stability (a two-sided measure). In terms of central deterrence, both the U.S. and Russia could suffer enormous amounts of damage from a retaliatory strike, no matter which side struck first. At lower levels of warhead inventories, planners may have to consider reviving older targeting strategies, even extending to city busting.

When deterrence is examined during potential crisis situations using first strike stability as a measure, deterrence at low levels of nuclear arsenals remains intact. Some improvement in first strike stability may be desired and could be achieved with modest improvements in alert or at-sea rates for strategic forces on both sides.

Deployment of anti-ballistic missile (ABM) defenses degrades first strike stability. The degree of degradation due to ABM is a function of the number of ABM interceptors deployed. Some members of Congress advocate the deployment of a national ABM system to protect the U.S. from ballistic missile attacks by so-called "rogue" governments. There seems to be no interest in protecting the U.S. from other likely forms of attack, such as aircraft carrying nuclear weapons or other weapons of mass destruction. Unless defenses are deployed against all forms of attack by rogue nations, it would seem to make little sense to deploy limited defenses to counter a single mode of delivering weapons of mass destruction.

Launch on Warning

The issue of whether or not nuclear armed ballistic missiles should be launched on warning of an attack has been resurrected from time to time, usually as a result of advances in reducing weapon system delivery errors, and then discarded because such a tactic is perceived to be extremely dangerous. Such dangers could become critical at lower levels of nuclear weapons.

Launch on warning is often perceived as an easy way of compensating for increased vulnerability of basing schemes for ballistic missiles. Perceived lower delivery errors have often led to perceived lowering of the survivability of silos or docked submarines. One "solution" suggested at times has been implementation of a launch on warning tactic. Under this tactic, the survivability of a ballistic missile would be its availability rate (0.9 or so) rather than its probability of being severely damaged by an enemy's nuclear warhead, a reflection of the "use it or loose it" syndrome.

Whether or not ballistic missiles could be launched on warning is dependent on the solutions to the many problems involved. How sure can a commander be that a devastating attack is underway? Is there enough time available to make a profound and irreversible decision and transmit it to all ballistic missile bases? Could a large fraction of the ballistic missile forces be launched before enemy warheads arrive?

In this report, the confidence of a comander that an attack was underway was examined using techniques borrowed from Bayesian statistics. The results of this analysis indicated that high levels of confidence could be achieved if enough warning messages could be received and validated in the time available. In a worst case analysis for the Russians (no launch detection capabilities), the available time could be as short as ten or twelve minutes for an attack by SLBMs. Answers were not found to questions concerning the feasibility due to other problems such as the time taken by a head of state to order a launch, the impact of current war plans regarding the time of arrival of retaliatory warheads, restricting the number of open silo lids in any given time interval, and, finally, the availability, launch readiness, or range limitations of the retaliatory missiles, be they in silos or aboard docked submarines. It was assumed that all SLBMs and ICBMs on either side could be launched on warning for the most effective retaliation. This assumption may be in error for the U.S. submarine force, but was made to examine worst case scenarios. Based on our examination, there may be a slight chance that launch on warning could be implemented. Because of the unknown chance that indications and warnings might not be forthcoming, or that warning messages might be in error, launch on warning tactics could be very dangerous. If there is an error concerning the warning of an attack, one consequence of a rapid retaliation could be societal obliteration.

As might be expected, the apparent increase in the survivability of ballistic missiles that could be launched on warning is reflected in estimates of first strike stability. However, analyses of first strike stability do not capture the inherent dangers of launching on warning. Increases in first strike stability could be achieved with other less risky methods than launch on warning, such as increased alert or at-sea rates

for ballistic missiles. Maintaining a high degree of first strike stability is dependent on the survivability of nuclear forces in the U.S. and Russia. One extreme possibility of limiting the dangers inherent in launch on warning would be to phase out ballistic missiles whose basing schemes are vulnerable to attack. The author believes that all silo based ICBMs should be eliminated as a first step in meeting this objective.

In the past, the launch on warning policy of the U.S. was vague, leaving a potential attacker with a huge uncertainty concerning this issue in planning an attack. Under the current administration plans, the policy appears to be that **retaliatory forces will not be launched on warning.**

Breaking Out From Future Agreements

Cheating or sudden abrogation of a future arms control agreement could lead to a sudden increase in the number of nuclear warheads deployed by one side. In this report, two issues were addressed: the potential damage to U.S. assets if the Russians should break out, and the effects of such a breakout on first strike stability, assuming that warheads on ICBMs and SLBMs were increased.

At lower levels of strategic nuclear arsenals, 2500 or 800 warheads, a sudden abrogation by Russia could more than double the number of deployed warheads. This increase in warheads effectively would cause a large increase in potential damage should the Russians undertake a first strike. If the U.S. were to deploy more warheads in response to a Russian breakout, then the U.S. would also be able to inflict substantial damage to Russian valued assets. While a Russian breakout could convey an alarming increase in potential damage to the U.S., such increases could result in a higher value of first strike stability under potential terms of a START III accord. At a lower limit of 800 warheads, a Russian breakout would provide a small increase in first strike stability. If the U.S. responded by uploading ICBMs and SLBMs, first strike stability would be substantially increased, but both Russia and the U.S. would have many more warheads than were originally the central focus of negotiation and arms reduction. What then was the purpose of any agreement?

One purpose of future arms control agreements could be to reduce the strategic nuclear inventories of the U.S. and Russia, and to keep such new levels low. Avoiding cheating or potential breakout conditions would be a primary goal in negotiating such agreements. Both sides would need to agree to comprehensive verification and confidence building measures to assure each other that increases in nuclear warheads are detectable and that such increases would not be tolerated.

APPENDIX

The purpose of this appendix is to provide details of population attacks on U.S. and Russian cities. Figures 4 and 5 in the main body of this report are based on the data contained on Table A-1 and A-2 of this appendix. These details may be of concern to residents of the metropolitan areas shown.

Table A-1 is data obtained from the Bureau of the Census, United States Department of Commerce [11]. The form of the data has been rearranged into a rank order by population density. The columns tabulate the population, the land area of each population zone, the density of each zone, the per cent of the population living in that zone, the rank according to population density, and the cumulative per cent of the population. The last column indicates the number of one megaton nuclear weapons needed to cover the zone in question with an overpressure of at least one pound per square inch (1 psi).

Table A-2 is data taken from the 1996 edition of the World Book [9]. This data set did not include specifics concerning land area of the cities or districts involved. The allocation of weapons was based on using one megaton weapons in proportion to the population. The algorithm for allocation for each city is:

$$N = \mathrm{INT}[\mathrm{population(millions)}]+1,$$

where N is the number of one megaton nuclear warheads, and INT signifies the integer value of the amount in the brackets.

Neither table contains the entire population distribution of the U.S. or Russia. The part shown indicates shows the population involved up to about 33 per cent of the total, the upper limit of Robert S. McNamara's assured destruction criteria concerning casualties. The full tabulations are available on request from the author.

Table A-1 - Partial Population Distribution of the U.S.

1990 CENSUS DATA (RANKED BY POPULATION DENSITY) METROPOLITAN AREA (MSA, CMSA, PMSA)	POPULATION [MILLIONS]	LAND AREA [SQ MILES]	POPULATION PER SQ MILE [1000'S]	PERCENT OF POP	RANK	CUMUL PERCENT	1 MT WPNS TGTED >= 1 PSI	CUM 1 MT WPNS TGTED	CUMULATIVE POPULATION [MILLIONS]
JERSEY CITY, NJ PMSA (NYC)	0.5531	46.7	11.844	0.2224	1	0.222	1	1	0.5531
NEW YORK, NY PMSA (NYC)	8.5468	1147.6	7.448	3.4365	2	3.659	2	3	9.0999
CHICAGO, IL PMSA	6.0700	1884.3	3.221	2.4406	3	6.099	3	6	15.1699
ANAHEIM SANTA ANA, CA PMSA (LAX)	2.4106	789.7	3.053	0.9692	4	7.069	2	8	17.5805
BERGEN PASSAIC, NC PMSA (NYC)	1.2784	419.3	3.049	0.5140	5	7.583	1	9	18.8589
LOS ANGELES LONG BEACH, CA PMSA (LAX)	8.8632	4060.0	2.183	3.5637	6	11.146	7	16	27.7221
NEW BRITAIN, CT PMSA (HAR CT)	0.1482	85.5	1.733	0.0596	7	11.206	1	17	27.8703
BRIDGEPORT MILFORD, CT PMSA (NYC)	0.4437	261.9	1.694	0.1784	8	11.384	1	18	28.3140
STAMFORD, CT PMSA (NYC)	0.2026	120.6	1.680	0.0815	9	11.466	1	19	28.5166
BOSTON, MA PMSA (BOSTON)	2.8707	1760.2	1.631	1.1542	10	12.620	3	22	31.3873
SAN FRANCISCO, CA PMSA (SFO)	1.6037	1015.6	1.579	0.6448	11	13.265	2	24	32.9910
NEWARK, NJ PMSA (NYC)	1.8243	1219.9	1.495	0.7335	12	13.998	2	26	34.8153
TRENTON, NJ PMSA (PHIL)	0.3258	226.0	1.442	0.1310	13	14.129	1	27	35.1411
OAKLAND, CA PMSA (SFO)	2.0819	1457.8	1.428	0.8371	14	14.966	2	29	37.2230
NORWALK, CT PMSA (NYC)	0.1274	89.6	1.422	0.0512	15	15.018	1	30	37.3504
HONOLULU, HI MSA	0.8362	600.2	1.393	0.3362	16	15.354	1	31	38.1866
PHILADELPHIA, PA-NJ PMSA (PHIL)	4.8569	3518.1	1.381	1.9528	17	17.307	6	37	43.0435
BROCKTON, MA PMSA (BOSTON)	0.1895	147.5	1.285	0.0762	18	17.383	1	38	43.2330
LOWELL, MA-NH PMSA (BOSTON)	0.2731	216.9	1.259	0.1098	19	17.493	1	39	43.5061
NEW HAVEN MERIDEN, CT MSA	0.5302	430.1	1.233	0.2132	20	17.706	1	40	44.0363
SALEM GLOUSTER, MA PMSA (BOSTON)	0.2644	216.1	1.224	0.1063	21	17.812	1	41	44.3007
CLEVELAND, OH PMSA (CLE)	1.8311	1512.2	1.211	0.7362	22	18.548	2	43	46.1318
SAN JOSE CA PMSA (SFO)	1.4976	1291.2	1.160	0.6021	23	19.151	2	45	47.6294
LAKE COUNTY, IL PMSA (CHICAGO)	0.5164	447.8	1.153	0.2076	24	19.358	1	46	48.1458
PAWTUCKET WOONSOCKET ATTLEBORO, RI-MA PMSA (PROV)	0.3294	306.7	1.074	0.1324	25	19.491	1	47	48.4752
PROVIDENCE, RI PMSA (PROV)	0.6549	611.5	1.071	0.2633	26	19.754	1	48	49.1301
FT LAUDERDALE HOLLYWOOD POMPANO BEACH, FL PMSA (MIA	1.2555	1208.9	1.039	0.5048	27	20.259	2	50	50.3856
MIAMI HIALEAH, F. PMSA (MIAMI)	1.9371	1944.7	0.996	0.7789	28	21.038	3	53	52.3227
WATERBURY, CT MSA	0.2316	233.5	0.992	0.0931	29	21.131	1	54	52.5543
WASHINGTON, DC-MD-VA MSA	3.9236	3966.7	0.989	1.5776	30	22.708	7	61	56.4779
DETROIT, MI PMSA (DET)	4.3823	4465.6	0.981	1.7620	31	24.470	8	69	60.8602
MILWAUKEE, WI PMSA (MIL)	1.4321	1460.0	0.981	0.5758	32	25.046	3	72	62.2923
MIDDLESEX SOMERSET HUNTERDON, NJ PMSA (NYC)	1.0198	1045.5	0.975	0.4100	33	25.456	2	74	63.3121
FALL RIVER, MA-RI PMSA (PROV)	0.1573	162.5	0.968	0.0632	34	25.519	1	75	63.4694
BRISTOL, CT PMSA (HART CT)	0.0749	78.0	0.960	0.0301	35	25.550	1	76	63.5443
BALTIMORE, MD MSA	2.3822	2609.3	0.913	0.9578	36	26.507	5	81	65.9265
RACINE, WI PMSA (MIL)	1.6072	1793.1	0.896	0.6462	37	27.154	3	84	67.5337
SPRINGFIELD, MA MSA	0.5295	594.2	0.891	0.2129	38	27.366	1	85	68.0632
MONMOUTH OCEAN, NJ PMSA (NYC)	0.9863	1108.2	0.890	0.3966	39	27.763	2	87	69.0495
LAWRENCE HAVERHILL, MA-NH PMSA (BOSTON)	0.3935	462.2	0.851	0.1582	40	27.921	1	88	69.4430
NORFOLK VIRGINIA BEACH NEWPORT NEWS VA MSA	1.3961	1685.4	0.828	0.5613	41	28.483	3	91	70.8391
NASSAU SUFFOLK, NY PMSA (NYC)	0.9863	1198.0	0.823	0.3966	42	28.879	2	93	71.8254
NEW BEDFORD, MA MSA	0.1756	214.2	0.820	0.0706	43	28.950	1	94	72.0010
TAMPA ST.PETE CLEARWATER, FL MSA	2.0680	2554.5	0.810	0.8315	44	29.781	4	98	74.0690
BUFFALO NIAGARA FALLS, NY CMSA	1.1893	1567.6	0.759	0.4782	45	30.259	3	101	75.2583
AKRON, OH PMSA (CLE)	0.6576	905.2	0.726	0.2644	46	30.524	2	103	75.9159
HARTFORD, CT PMSA (HART CT)	0.7678	1074.2	0.715	0.3087	47	30.833	2	105	76.6837
MANCHESTER, NH MSA	0.1478	215.0	0.687	0.0594	48	30.892	1	106	76.8315
CINCINNATI, OH-KY-IN PMSA (CINCIN)	1.4526	2125.0	0.684	0.5841	49	31.476	4	110	78.2841
FLINT, MI MSA	0.4305	639.7	0.673	0.1731	50	31.649	1	111	78.7146
SALT LAKE CITY OGDEN, UT MSA	1.0722	1617.5	0.663	0.4311	51	32.080	3	114	79.7868
GARY HAMMOND, IN PMSA (CHICAGO)	0.6045	915.2	0.661	0.2431	52	32.323	2	116	80.3913
WORCESTER, MA MSA	0.4369	702.1	0.622	0.1757	53	32.499	2	118	80.8282
HOUSTON, TX PMSA (HOU)	3.3019	5321.8	0.620	1.3276	54	33.827	9	127	84.1301

Table A-2 - Partial Population Distribution of Russia

RUSSIAN CITIES IN DESCENDING ORDER OF POPULATION NAME OF CITY	POPULATION [MILLIONS]	CUMULATIVE POPULATION [MILLIONS]	RANK	WARHEADS PER CITY	WARHEADS TOTAL	CUMULATIVE POPULATION [PER CENT]
MOSCOW	8.967	8.967	1	9	9	6.099
ST. PETERSBURG	5.020	13.987	2	6	15	9.514
NIZHNIY NOVGOROD	1.443	15.430	3	2	17	10.495
NOVOSIBIRSK	1.443	16.873	4	2	19	11.477
YEKATERINBURG	1.372	18.245	5	2	21	12.410
SAMARA (KUYBYSHEV)	1.258	19.503	6	2	23	13.265
OMSK	1.159	20.662	7	2	25	14.054
CHELYABINSK	1.148	21.810	8	2	27	14.835
KAZAN	1.103	22.913	9	2	29	15.585
PERM	1.094	24.007	10	2	31	16.329
UFA	1.094	25.101	11	2	33	17.073
ROSTOV-ON-DON	1.025	26.126	12	2	35	17.770
VOLGOGRAD	1.005	27.131	13	2	37	18.454
KRASNOYARSK	0.922	28.053	14	1	38	19.081
SARATOV	0.908	28.961	15	1	39	19.698
VORONEZH	0.895	29.856	16	1	40	20.307
VLADIVOSTOK	0.643	30.499	17	1	41	20.745
TOLYATTI	0.642	31.141	18	1	42	21.181
IZHEVSK (USTINOV)	0.642	31.783	19	1	43	21.618
ULYANOVSK	0.638	32.421	20	1	44	22.052
YAROSLAVL	0.636	33.057	21	1	45	22.484
IRKUTSK	0.635	33.692	22	1	46	22.916
KRASNODAR	0.627	34.319	23	1	47	23.343
KHABAROVSK	0.608	34.927	24	1	48	23.756
BARNAUL	0.603	35.530	25	1	49	24.166
NOVOKUZNETSK	0.601	36.131	26	1	50	24.575
ORENBURG	0.552	36.683	27	1	51	24.951
PENZA	0.548	37.231	28	1	52	25.323
TULA	0.543	37.774	29	1	53	25.693
RYAZAN	0.522	38.296	30	1	54	26.048
KAMEROVO	0.521	38.817	31	1	55	26.402
ASTRAKHAN	0.510	39.327	32	1	56	26.749
NABEREZHNYYE CHELNY	0.507	39.834	33	1	57	27.094
TOMSK	0.506	40.340	34	1	58	27.438
TYUMEN	0.487	40.827	35	1	59	27.769
KIROV	0.487	41.314	36	1	60	28.101
IVANOVO	0.482	41.796	37	1	61	28.428
MURMANSK	0.472	42.268	38	1	62	28.749
BRYANSK	0.456	42.724	39	1	63	29.060
LIPETSK	0.455	43.179	40	1	64	29.369
TVER (KALININ)	0.454	43.633	41	1	65	29.678
MAGNITOGORSK	0.443	44.076	42	1	66	29.979
NIZHNIY TAGIL	0.440	44.516	43	1	67	30.278
KUR	0.430	44.946	44	1	68	30.571
CHEBOKSARY	0.429	45.375	45	1	69	30.863
ARKHANGELSK	0.419	45.794	46	1	70	31.148
KALININGRAD (KONIGSBERG)	0.406	46.200	47	1	71	31.424
GROZNYY	0.401	46.601	48	1	72	31.697
CHITA	0.372	46.973	49	1	73	31.950
KURGAN	0.360	47.333	50	1	74	32.195
ULAN-UDE	0.359	47.692	51	1	75	32.439
VLADIMIR	0.353	48.045	52	1	76	32.679
SMOLENSK	0.346	48.391	53	1	77	32.914
OREL	0.342	48.733	54	1	78	33.147
MAKHACHKALA	0.327	49.060	55	1	79	33.369

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July 9, 1998

Mr. Frank V. Scott, Jr.
Chief, Acquisitions Branch, Room 0825
Defense Technical Information Center
8725 John J. Kingman Road, Suite 0944
Fort Belvoir, VA 22060-6218

Dear Frank:

Each year I usually have a paper at MORS and send a copy to your organization. This year is no exception. Enclosed is a copy of **Some Potential Risks at Lower Levels of Strategic Nuclear Weapon Arsenals**, and your form 298 filled out with the pertinent data. Bob Batcher at ACDA, (202) 736-7396, signed the release for unlimited distribution and certified that the paper is unclassified.

If you or your staff have any questions, please do not hesitate to call me in Minnesota until September 1, 1998. Thereafter, contact me in Colorado. I appreciate your assitance in getting the report distributed to interested parties.

Sincerely,

Fred

Frederic S. Nyland

Enclosures: R-126-ACDA, Standard Form 298

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